FORM PTO-1390 (Modified)
(REV 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER

217753US2PC1 **10019277**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

09/926846

INTERNATIONAL APPLICATION NO. **PCT/FR99/01690**	INTERNATIONAL FILING DATE **9 July 1999**	PRIORITY DATE CLAIMED **none**

TITLE OF INVENTION

TRACK-FOLLOWING SYSTEM FOR THE RECORDING/READING OF A DATA MEDIUM AND RECORDING MEDIUM

APPLICANT(S) FOR DO/EO/US

COLINEAU Joseph et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.

4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))

    a. ☐ is attached hereto (required only if not communicated by the International Bureau).

    b. ☒ has been communicated by the International Bureau.

    c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

    a. ☒ is attached hereto.

    b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))

    a. ☐ are attached hereto (required only if not communicated by the International Bureau).

    b. ☐ have been communicated by the International Bureau.

    c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

    d. ☒ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).

10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).

12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

15. ☐ A **FIRST** preliminary amendment.

16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.

17. ☐ A substitute specification.

18. ☐ A change of power of attorney and/or address letter.

19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

22. ☐ Certificate of Mailing by Express Mail

23. ☒ Other items or information:

    Drawings (5 sheets)
    PCT/IB/308
    Form PTO-1449

PCTUS1/REV03

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/019277	PCT/FR99/01690	217753US2PCT

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS PTO USE ONLY

☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**

☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**

☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =	**$890.00**	

Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)). **$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	10 - 20 =	0	x $18.00	$0.00	
Independent claims	2 - 3 =	0	x $84.00	$0.00	
Multiple Dependent Claims (check if applicable).			☐	$0.00	

TOTAL OF ABOVE CALCULATIONS =	**$890.00**	

☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2. **$0.00**

SUBTOTAL =	**$890.00**	

Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). + **$0.00**

TOTAL NATIONAL FEE =	**$890.00**	

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐ **$0.00**

TOTAL FEES ENCLOSED =	**$890.00**	

Amount to be: refunded	$
charged	$

a. ☒ A check in the amount of _____$890.00_____ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. _____15-0030_____ A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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Jan. 2 2002
DATE

TRACK-FOLLOWING SYSTEM FOR THE RECORDING/READING OF A
DATA MEDIUM AND RECORDING MEDIUM

5 The invention relates to a track-following system for the recording/reading of a data medium, especially for a multitrack data medium such as a magnetic tape with multitracks placed longitudinally over the tape.

10 The invention is applicable especially to reading magnetic or optical recordings and, in this context, to the reading of a high-density recording. It is preferably applicable in recording systems such as computing peripherals and all professional systems.

15 The invention can be extended to recordings on optical tape and on magnetic or optical disk, when it is desired to read several tracks in parallel therefrom.

20 High-density recording on parallel tracks presents a twofold problem for track following and separation rereading. The small width of the tracks (less than 20 μm) means that it is difficult on reading a tape to ensure the accuracy of track following on the basis of the single mechanical guidance at the edge of the tape.

25

The need to guarantee the interoperability of the tapes and of the readers aggravates this difficulty.

30 Moreover, obtaining a high signal-to-noise ratio on reading requires rereading the entire track width, which excludes the existence of a barrier between tracks and induces track-to-track reading cross-talk phenomena.

35 The increase of the longitudinal track density of linear record/read systems makes it necessary to put in place high-performance track-following systems, making it possible to position the read system facing tracks written with a small residual error compared to the

track width. This is because the accuracy of positioning and of guidance given by the tape transport mechanism is no longer enough to naturally guarantee good positioning.

5

Some systems make recordings possible on adjoining tracks with a step less than 10 μm. Reading a recording of this sort may be done optically as is described in French patent No. 89 17313 (see figure 1). A multipixel

10 detection device TL6 receives a light beam carrying data read on the magnetic tape BD. So that the pixels receive the track data from the tape and that each may read a specific track, a system TL5 for deflecting the read beam is provided between the tape and the

15 detection device. For example, a mirror or plate activator makes it possible to deflect the optical read beam at a speed high enough to continuously provide the proper positioning of the pixel of the detection device with respect to the corresponding tracks.

20

The track-following systems usually implemented in linear recorders are based on the continuous or periodic reading of one or more control tracks on which defined signals ("pilot" frequencies for example) have

25 been recorded. A position error signal is extracted from the processing of the signal of this (these) track(s), and acts on an actuator, which displaces the read beam with respect to the detectors.

30 In the case of multitrack technology with an optical reader, the simultaneous access to a large number of adjoining tracks makes it possible for an error signal to be directly prepared from the observation of the read cross-talk between these tracks. The error signal

35 may then be exploited in order to control the position of the actuator.

French patent No. 92 15474 describes a control device based on this method. This system provides "relative"

positioning, that is to say that it allows the proper centering of the photosensitive elements of the read detector (pixels) on the center of the reread tracks. It is completed by a second device which prepares an
5 error signal if the relative positioning does not make the pixel j correspond to the track j.

The invention supplies a system which has a shorter response time than the known systems and which allows a
10 faster track-following correction. Furthermore, this system is less restrictive for the recording format.

The invention therefore relates to a system for reading a magnetic medium having several tracks of data which
15 can be read in parallel, and comprising a detection device having at least as many detectors as there are tracks, making it possible to read simultaneously and at regular intervals a sample of data on each track, said detection device having a parallel/series shift
20 register receiving in parallel the samples of data read by the detectors at each read time and retransmitting them in series form, characterized in that it comprises:
   ♦   a processing circuit receiving each sample of data
25   to be processed from each track, together with the
        sample of a first adjacent track and the sample of
        a second adjacent track, multiplying the value of
        said sample to be processed:
        - by +1 when the sample of the first adjacent
30   track is negative and the sample of the second
           adjacent track is positive;
        - by -1 when the sample of the first adjacent
           track is positive and the sample of the second
           adjacent track is negative;
35   - by 0 when the samples of the adjacent tracks
           are of the same sign;
   ♦   an integration circuit receiving each sample value
        thus multiplied, integrating said values obtained

at each read time, then integrating the values
obtained at following read times;

♦ a relative track-following control circuit
receiving the result of integration of the
integrator circuit and supplying a track-following
control signal for the detection device.

The invention also relates to a recording medium
comprising several tracks recordable in parallel,
characterized in that said tracks each comprise a
preamble zone recorded or recordable in parallel, said
zones containing data making it possible to locate the
tracks one with respect to the others.

The various objects and characteristics of the
invention will become more clearly apparent in the
following description made by way of example and in the
appended figures which show:

- figure 1, a magnetic tape read system known in
  the prior art;
- figure 2, a general exemplary embodiment of the
  system of the invention;
- figure 3, an example of positioning detectors
  with respect to the tracks of a magnetic tape;
- figure 4, a general exemplary embodiment of a
  circuit for detecting the relative position of
  tracks of a recording medium with respect to a
  detection device;
- figure 5, a detailed exemplary embodiment of
  the circuit of figure 4;
- figure 6, a detection device combined with a
  multitrack recording medium;
- figure 7, an organizational example of an
  absolute track-following system according to
  the invention;
- figure 8, an example of a circuit making it
  possible to implement an absolute track-
  following control circuit according to the
  invention.

According to the invention, the function of preparing the error signal is independent of the cross-talk correction system, which makes the independent

5   optimization of the two functions possible. Moreover, the absolute positioning method no longer requires the use of a particular modulation code to which violations have just been made, but is based on independent zones of the data zones, thus making it possible to use any

10   type of modulation code adapted to the channel. The particular signals used for the absolute positioning may be chosen according to the overall performance desired (time for detecting the absolute position). Finally, absolute and relative positions are now

15   dissociated, which makes a much shorter establishment time possible.

The general operation is as follows:
- the read system has a greater number of

20   elements (pixels) than the number of tracks;
- the relative positioning loop aligns the pixels on the closest tracks;
- a system for detecting absolute position determines where the physical tracks are

25   located or, which is equivalent, indicates the number of the pixel corresponding to the first track (track 0);
- the read electronics processes the signals from all the pixels;

30   - the position data of the tracks is transmitted to the electronics for processing decoded data, which, itself, only processes the data from the physical tracks.

35   Figure 2 shows a general diagram of the system of the invention. This system comprises a detection device TL6 comprising a row of detectors tli. The width of this row of detectors is wider than the width of the tape BD to be read. For example, as indicated in figure 2, for

80 tracks, the detector device TL6 comprises 96 detectors tli. The detector device TL6 comprises in a known manner a circuit CCD (not shown) making it possible to transmit the signals detected on the tracks to the processing circuits. These processing circuits comprise an analog-digital converter CAN and a digital processor CC capable of processing the data from the 96 detectors. A circuit DTR for positioning the detection device with respect to the tracks is combined with the processor CC and controls a system TL5 for controlling the position of the detection device with respect to the tracks. A circuit DTA for detecting the absolute position of the detectors with respect to the tracks is also combined with the processor in order to indicate the relationship of the position of the detectors with respect to the tracks.

First of all, we will describe the design and an exemplary embodiment of the relative positioning circuit DTR.

In an ideal multitrack read system, each read element i delivers, at time k, a signal $x_{i(k)}$ proportional to the symbol $a_{i(k)}$ written on this track.

In practice, the read signal undergoes deformations owing to

1 - the presence of noise $b_{(k)}$

2 - interference between successive symbols of one and the same track (intersymbol interference) as a result of the limited bandwidth of the channel

3 - interference between adjacent track symbols (intertrack cross-talk) as a result of separation faults between tracks of the read system

4 - interference between symbols of adjacent tracks as a result of faults in positioning and guiding of the recording medium or of the read/write heads.

Figure 3 shows a set of parallel tracks of width w, and the read system, positioned with a separation d with respect to the optimum position.

5 The read signal of the head element i at time k is equal to:

$$x_{i(k)} = \left(1 - \frac{d}{w}\right) \cdot a_{i(k)} + \frac{d}{w} \cdot a_{i-1(k)} + b_{(k)}$$

10 Let us assume that the signal $a_{i-1(k)}$ written on the track i-1 is known. It is possible to calculate the intercorrelation of $x_{i(k)}$ and of $a_{i-1(k)}$.

$$C_{i,i-1} = \frac{1}{N} \sum_k x_{i(k)} \cdot a_{i-1(k)}$$

15

$$C_{i,i-1} = \frac{1}{N} \sum \left[\left(1 - \frac{d}{w}\right) \cdot a_i + \frac{d}{w} a_{i-1(k)} + b_{(k)}\right] a_{i-1(k)}$$

$$C_{i,i-1} = \frac{1}{N} \sum \left[\left(1 - \frac{d}{w}\right) \cdot a_{i(k)} \cdot a_{i-1(k)} + \frac{1}{N} \sum \frac{d}{w} a_{i-1(k)} \cdot a_{i-1(k)} + \frac{1}{N} \sum b_{(k)} \cdot a_{i-1(k)}\right]$$

20 The first term represents the intercorrelation of the signals written on the tracks i and i-1. If the signals of the tracks are statistically independent, this term is zero.

25 Likewise, the last term represents the intercorrelation of the noise and of the signal. If the noise is independent of the signal, this term is zero.

The second term represents the autocorrelation of the
30 signal of the track i-1. This is the energy of the signal over n samples. It is constant on average, and we will take it to be equal to 1 by convention.

Thus

35

$$C_{i,i-1} = \frac{1}{N}\sum \frac{d}{w} \cdot a_{i-1(k)} \cdot a_{i-1(k)} \approx \frac{d}{w}$$

In the case shown in the figure, $C_{i,i+1}$ is zero. If the separation of the detector with respect to the tracks is in the other direction,

$$C_{i,i-1} = 0$$

$$C_{i,i+1} \approx \frac{d}{w}$$

It is therefore possible to extract a position error signal based on the signals of the track i:

$$C_{i,i-1} - C_{i,i+1} \approx \frac{d}{w}$$

In order to improve the quality of this signal, it is advantageous to carry out this calculation for each of the tracks, and to take the average of the results

$$\frac{d}{w} \approx \frac{1}{p}\sum \left[C_{i,i-1} - C_{i,i+1} \right]$$

According to the invention, the calculation is carried out directly, in order to overcome the response time and rounding off restrictions for optimum operation of the cross-talk corrector.

At time k:

$$\mathring{a}(k) = \frac{1}{p}\sum_{i} C_{i,i-1}(k) - C_{i,i+1}(k)$$

$$C_{i,i-1} = \frac{1}{N}\sum_{k} x_{i(k)} \cdot a_{i-1(k)}$$

The signals $a_{i(k)}$ recorded on the tracks are approximated by the sign of the samples reread on this

track. A simplified decoding of the signal is thus carried out. The benefit of this simplified decoding is that it is not necessary to wait for the convergence of the various devices for processing the signal that is generally found in the read channel (adaptive equalizer, PLL, etc.) to make the decoded signal available. The approximation only generates excess noise in the position error estimate:

$$C_{i,i-1} \# \frac{1}{N} \sum_k x_i(k) \cdot sgn(x_{i-1}(k))$$

hence:

$$\mathring{a}(k) = \frac{1}{NP} \sum_i \sum_k \left[x_i(k) \cdot sgn(x_{i-1}(k)) - x_i(k) \cdot sgn(x_{i+1}(k)) \right]$$

or else:

$$\mathring{a}(k) = \frac{1}{NP} \sum_i \sum_k x_i(k) \cdot \left[sgn(x_{i-1}(k)) - sgn(x_{i+1}(k)) \right]$$

This last form makes it particularly easy to insert the algorithm.

Figure 4 shows a simplified exemplary embodiment of the relative positioning circuit DTR.

This circuit receives at its input IN the data samples transmitted on the series output of the CCD of the detection device TL6. Each successive sample is transmitted to a multiplier M1 where it is multiplied by a factor 1, -1 or 0 supplied by the circuit DS depending on the signs of the adjacent samples.

The samples multiplied in this way are integrated in an integration circuit I1. The output OUT of the integrator supplies an error signal making it possible

to correct the relative position error of the detection device with respect to the tracks.

The circuit DS makes it possible to determine the cross-talk correction multiplication factor K for each sample. For a sample x_1, this factor K takes one of the values -1, +1 or 0 by applying the following table:

Value of the factor K	Sign of the sample x_{i-1}	Sign of the sample x_{i+1}
-1	> 0	< 0
+1	< 0	> 0
0	> 0	> 0
0	< 0	< 0

It can therefore be seen that if the samples have the same sign, the factor K is zero. If they have opposite signs, the factor K has the value +1 or -1 as indicated by the table.

Figure 5 shows a detailed exemplary embodiment of the DTR circuit.

This circuit comprises two delay circuits R2 with equivalent delays making it possible to transmit at the same time as a sample x_1, the previous sample x_{1-1} and the following sample x_{i+1} to the multiplier M1. The sample x_1 is transmitted to the multiplier M1, firstly, as it is and, secondly, multiplied by -1. With regard to the samples x_{1-1} and x_{1+1}, only the signs of these samples are transmitted by the circuits sgn1 and sgn2. The circuit M1 also receives a signal representing the value 0 of a sample. The circuit M1 is designed to compare the signs of the samples x_{1-1} and x_{1+1} and to control, by applying the above table, the transmission on the output of the circuit M1, that is the signal $+x_i$, or the signal $-x_1$ or the signal 0.

The processing carried out on the successive samples contained in the CCD of the detection device TL6 are integrated into the integrator I1.

5 The data samples from the different tracks detected at a particular time and contained in the CCD register of the detection device are therefore processed one after the other as has just been described and the results of the processing are integrated into the integrator I1. 10 Next, the samples from the different tracks detected at the subsequent times are processed in the same way and integrated after the previous ones. The integration can be carried out in the same integrator I1.

15 The depth of the integrator depends on the mean amplitude of the samples, on their rate, and on the desired response time. By way of indication, for a rate of 15 million samples per second, a depth of about 20 bits makes it possible to obtain a bandwidth of the 20 control loop of about 30 Hz in order to obtain a short lock-on time without being detrimental to the accuracy of the system in normal operation, it is possible to change the time constant between the lock-on mode and the track-following mode.

25

The error signal coded over 8 bits consists of the high-weight bits of this integrator. It is then converted to an analog quantity, filtered then adapted to the control of the electromagnetic motor.

30

The result of the integration makes it possible to control the adjustment of the position of the detection device with respect to the tracks of the tape, or, which amounts to the same thing, in the case of optical 35 reading of the tracks, to adjust the deflection of the read beam towards the detection device. Since the detectors of the detection device are adjusted virtually on the centers of the tracks, the numbers of the tracks read should then be identified.

The relative position detection circuit DTR enabling the position of the detectors to be adjusted with respect to the centers of the tracks read will now be described. However, as has also been seen (figure 2), the detection device comprises a greater number of detectors than there are tracks. Nevertheless, all the detectors are taken into account in reading. It is therefore necessary to detect the detectors PHS1 and PHS2 which are not used in reading the tracks (figure 6). The absolute position detection circuit DTA makes it possible to detect these detectors and to identify the detector corresponding to the first track, that corresponding to the second track, etc.

According to the invention, zones called preamble zones, containing signals of particular characteristics in order to detect the tracks, are provided here and there on the recording medium.

In this preamble zone, at least some tracks, or even all the tracks, contain identification data making it possible to indicate the number of the tracks.

Under these conditions, after having positioned the detection device with respect to the tracks, the detectors which read identification data make it possible to identify the numbers of the tracks which they read.

The system therefore identifies, on the one hand, the detectors used for reading tracks and the numbers of the tracks that they read.

A method preferred according to the invention is to impose the signals having a positive or negative continuous component depending on the tracks, in the preamble zone.

Moreover, these signals will preferably have characteristics required by other considerations. For example, it is desirable that these signals have little track-to-track correlation so as not to cause the

5   malfunction of the relative position detection circuit DTR. Moreover, they must be capable of being transmitted and exploited correctly by the system (spectral characteristics adapted to the channel, probability of transitions allowing the proper

10   operation of the phase locked loop). For example, one method consists in using, for this region, pseudo-random signals coded according to the 8/10 modulation code or a set of specific words of this code, with alteration of the coding. In this system, only the

15   preamble zone is affected by this coding. A variant may consist in keeping this code in the data zones, if the 8/10 code is used in the data zone.

The 8/10 code with a zero continuous component has a

20   certain number of code words with a nonzero continuous component (DC = ±2). The normal use of this code provides that a word with a positive continuous component must be followed by a word with a negative continuous component. If this rule is violated

25   systematically or periodically, a nonzero continuous component is generated on the corresponding track. The integral of this continuous component is generally called DSV (Digital Sum Value). The idea is to make the DSV of each track moderately increasing or decreasing

30   according to a pattern defined for all the tracks and thus to create an absolute track reference. On reading, the increasing DSV tracks are then distinguished from the decreasing DSV tracks. On writing, the DSV of the tracks are made alternately increasing over n tracks

35   then decreasing over n following tracks.

This leads to a modification qualified as "alteration" on the algorithm of the initial coding. "Modulation of

the DSV" will also be mentioned in order to qualify an increasing or decreasing variation thereof.

The method for making a DSV increasing consists in not compensating a word coded DC = +2 with a word coded DC = -2 and of altering the DSV by therefore authorizing two consecutive words coded DC = +2. To make the DSV decreasing, it is enough, in contrast, to twice compensate a word coded DC = +2 by a word coded DC = -2 and therefore to authorize two consecutive words coded with DC = -2. It is also possible to systematically violate the encoding rule, which generates a stronger continuous component at the cost of a greater decoding penalty, if the continuous component is not reconstructed.

In order to evaluate the continuous component on a track, the series of decoded bits on this track are integrated for a given time, and it is examined whether the result is positive or negative.

Rather than integrate the decoded bits track by track, it is possible to make the correlation between the expected result and the result which is actually observed.

For example, for an alteration of an 8-track period DSV, that is to say 4 consecutive positive DSV tracks and 4 consecutive negative DSV tracks, the algorithm is as follows:

$S1 = sum \ [(b_0 + b_1 + b_2 + b_3) - (b_4 + b_5 + b_6 + b_7)]$

$S2 = sum \ [(b_2 + b_3 + b_4 + b_5) - (b_6 + b_7 + b_0 + b_1)]$

where b_i represents the signal samples of the track i modulo 8.

The value taken by S1 and S2 depending on the position of the tracks is represented in figure 7.

It is then possible to calculate from the values of S1 and S2, by means of a correspondence table, the difference in position of the tracks with respect to their theoretical position. A table of this sort is as follows:

S2 \ S1	-2	-1	0	1	2
-2			2		
-1		3			
0	4				0
1		5		7	
2			6		

Conversely, having calculated the values of S1 and S2, the shift of the tracks is thereby calculated.

In order to reduce the probability of error, it will be possible to normalize the values taken by S1 and S2 by noting that $|S1| + |S2| = $ constant.

It is therefore possible, by modulating the 8-track period DSV, to obtain data on the position of the modulo 8 tracks. If a larger range is required without uncertainty, it will be possible to increase this period.

A circuit carrying out this function is shown in figure 8.

Use of any code words

In the following, it is supposed that the code words are chosen randomly, but that a systematic violation of the encoding rule is applied according to the tracks.

The code comprises 256 words, of which 103 are with a nonzero DSV (DS = +2 or -2). For an equiprobable

message, the probability of occurrence of a nonzero DSV word is therefore 103/256. On average, the DSV of this sequence is:

+2*103/256 = 0.805

5   while the number of corresponding channel symbols is 10.

The continuous component generated by the code violation is then 0.08. This continuous component

10   barely penalizes the operation of the system, and in particular the decoding (0.72 dB). The noise on the error signal can be evaluated as follows:

For a measurement frequency of B = 100 Hz, the number

15   of symbols processed per integration period 1/B:

$$n = D/B$$

where D is the raw bit rate.

The fluctuation of the contents of the integrator is

20   Vn.

Typically, on a 64 track application, D = 10 Mb/s and Vn = 316.

25   In the case of a track difference, the error signal is then, over the same period:

$$0.08 * D/B = 8\ 000$$

That is, an S/N of 29 dB.

30

The optimum depth of the accumulator remains to be evaluated. It depends on the desired detection time.

Use of particular code words

35

In a preamble, it is possible to provide specific code words. In particular, it is possible to only use nonzero DSV words, which makes it possible to gain a factor 256/103 = 2.5, that is an improvement of 8 dB on

the S/N, with, however, a substantial increase in the penalty on the decoding (2 dB), which does not pose a problem in this preamble zone.

Use of words not belonging to the code table

It is quite possible to choose words not belonging to the 8/10 code, and to combine them within the track and between tracks, in order to optimize the overall operation of the system.

Other modes for detecting the position of the tracks

It is also possible to use other means for identifying the tracks, for example, a specific signal (pure frequency or single sequence) over one or more tracks. The criteria for choosing between solutions are the robustness (generally better if the detection is carried out on a set of tracks) and simplicity of implementation.

Exploitation of the absolute position signal

The detection system delivers a position signal (flag) of at least one track, for example the zero track, in synchronism with the decoded bits of this track (figure 2). This data is used by the system for rearranging data (deformatting electronics) in order to retain only the data corresponding to the tracks actually written (80/96 in our example).

CLAIMS

1. A system for reading a magnetic medium having
    several tracks of data which can be read in
5   parallel, and comprising a detection device having
    at least as many detectors as there are tracks,
    making it possible to read simultaneously and at
    regular intervals a sample of data on each track,
    said detection device having a parallel/ series
10 shift register receiving in parallel the samples
    of data read by the detectors at each read time
    and retransmitting them in series form,
    characterized in that it comprises:
    ♦ a processing circuit (M1) receiving each sample
15   of data (x_1) to be processed from each track,
      together with the sample $(x_{(1-1)})$ of a first
      adjacent track and the sample $(x_{(i+1)})$ of a second
      adjacent track, and calculating the cross-talk
      affecting the sample of data to be processed due
20   to the adjacent tracks;
    ♦ an integration circuit (I1) receiving the cross-
      talk value thus calculated, integrating said
      values obtained at each read time, then
      integrating the values obtained at following
25   read times;
    ♦ a relative track-following control circuit (CR)
      receiving the result of integration of the
      integrator circuit (I1) and supplying a track-
      following control signal for the detection
30   device.
    said processing circuit comprising means making it
    possible to multiply the value of the sample to be
    processed:
        - by +1 when the sample of the first adjacent
35   track is negative and the sample of the
          second adjacent track is positive;
        - by -1 when the sample of the first adjacent
          track is positive and the sample of the
          second adjacent track is negative;

- by 0 when the samples of the adjacent tracks
  are of the same sign.

2. The system as claimed in claim 1, characterized in
   that the data medium is read using a light beam
   which is transmitted to the detection device after
   reading the data medium, and in that the relative
   track-following control circuit (CR) makes it
   possible to control a device for deflecting the
   light beam depending on the position of the
   detection device.

3. The system as claimed in claim 1, characterized in
   that the detection device comprises a greater
   number of detectors than there are tracks to read
   and in that it comprises:
   - an absolute position detection circuit (CTA)
     making it possible to identify the track read
     by each detector of the detection device;
   - a central control circuit (CC) controlling
     the operation of said processing circuit (M1)
     of said integration circuit (I1) and of said
     relative track-following control circuit
     (CR), then of the absolute position detection
     circuit.

4. The system as claimed in claim 3, characterized in
   that it comprises means for identifying, in the
   data read by each detector, one or more track
   identity data items.

5. The system as claimed in claim 4, characterized in
   that the tracks of the data medium comprise
   preamble zones containing said identification
   data.

6. The system as claimed in claim 5, characterized in
   that the preamble zones of the various tracks can
   be read simultaneously.

7. The system as claimed in claim 6, characterized in that the preamble zones have components which are positive or negative depending on the tracks and in that a circuit makes it possible to detect the tracks with positive continuous components and those with negative continuous components.

8. The system as claimed in claim 7, characterized in that the tracks of the recording medium are distributed in alternating groups of positive and negative components.

9. The system as claimed in claim 8, characterized in that it comprises groups of four tracks of positive components which alternate with groups of four tracks of negative components and in that it comprises:
   - a first summation circuit (S1) adding the signs of the samples detected by a first group of four detectors (b0 to b3) and the inverse of the signs detected by a second group of four detectors (b4 to b7);
   - a second addition circuit (S2) adding the signs of the samples detected by the first two detectors of the first group of detectors and the last two detectors of the second group and the inverse of the signs of the samples detected by the other detectors of these groups of detectors;
   - a table indicating the numbers of the tracks detected by said detectors according to the results of the additions carried out by the addition circuits.

10. A recording medium comprising several tracks recordable in parallel, each one comprising a preamble zone recorded or recordable in parallel, said zones containing data making it possible to

locate the tracks one with respect to the others, characterized in that the preamble zones contain data with nonzero continuous components, the tracks being distributed in groups of tracks containing data with positive continuous components which alternate with groups of tracks with negative continuous components.
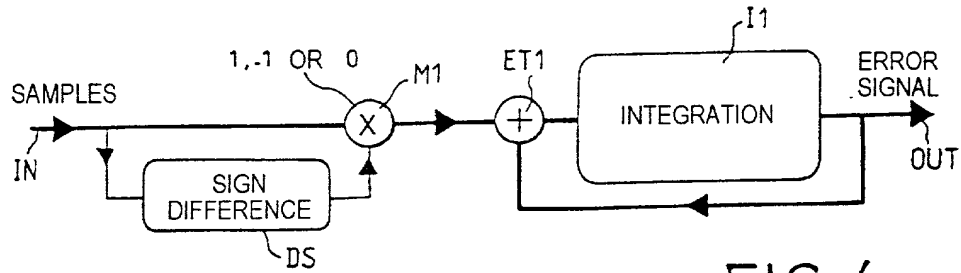
1/5

FIG.1
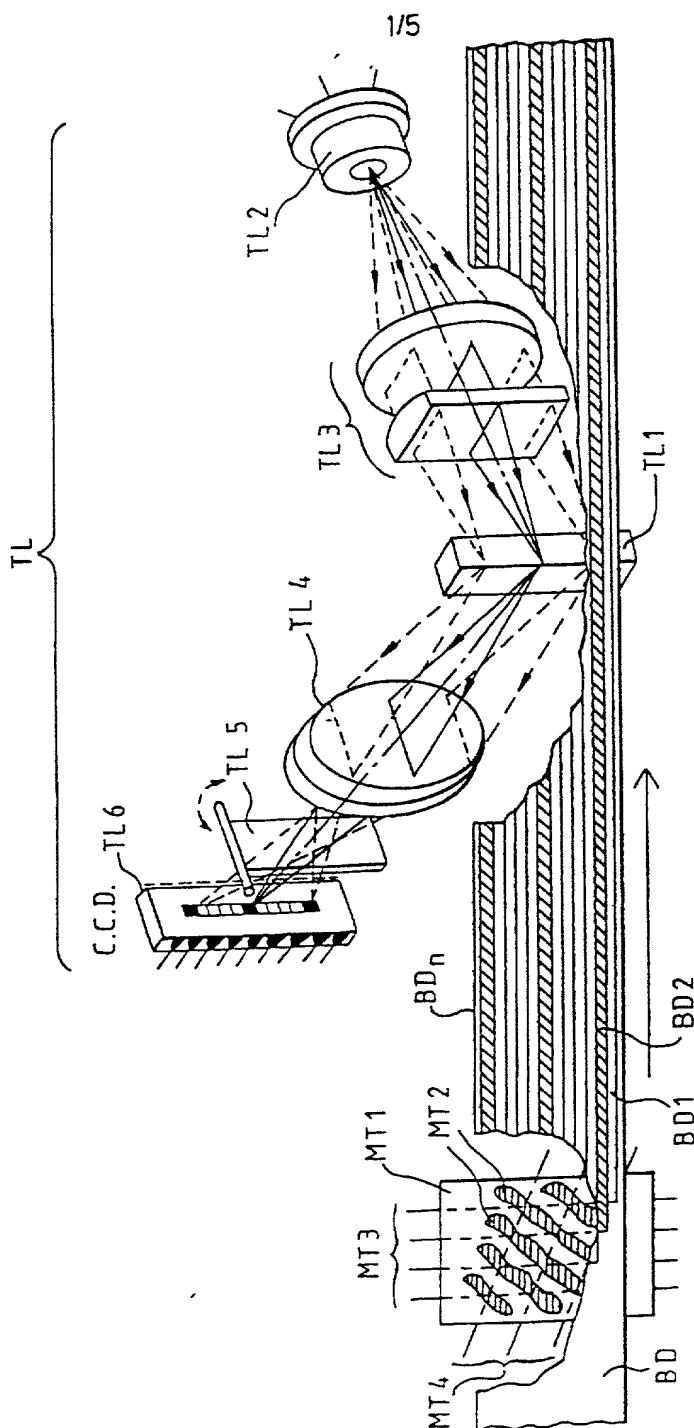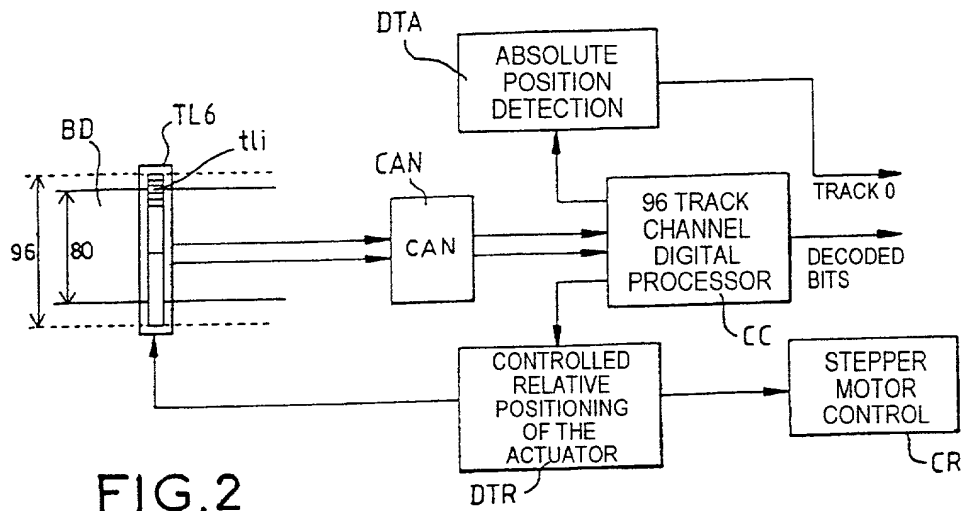
FIG.2

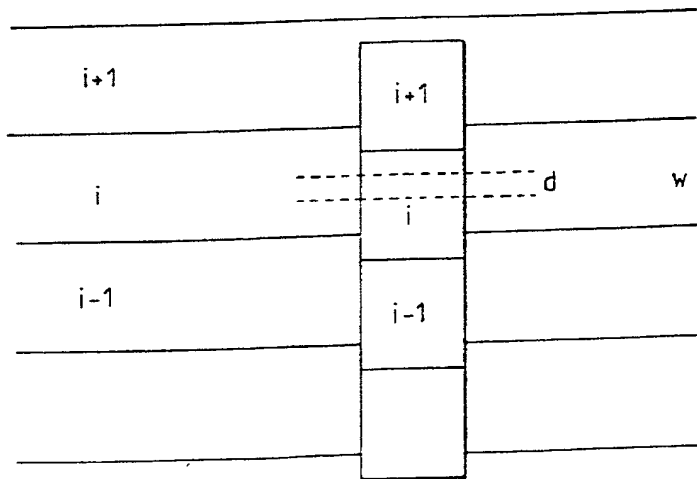- ABSOLUTE POSITION DETECTION (DTA)
- CAN
- 96 TRACK CHANNEL DIGITAL PROCESSOR (CC)
- TRACK 0
- DECODED BITS
- CONTROLLED RELATIVE POSITIONING OF THE ACTUATOR (DTR)
- STEPPER MOTOR CONTROL (CR)
- BD, TL6, tli
- 96, 80

FIG.3

- i+1
- i
- i-1
- d, w

SAMPLES

1,-1 OR 0

M1

ET1

I1

INTEGRATION

ERROR SIGNAL

IN

SIGN DIFFERENCE

DS

OUT

FIG.4

SAMPLES

ROUNDING FUNCTION

X(i-1)

R1

Z^{-1}

X(i)

R2

Z^{-1}

X(i+1)

-1

X

Sgn (Xi-1)

Sgn (Xi+1)

Sgn 1

Sgn 2

X(i)

-X(i)

M1

0

INTEGRATOR

I1

ERROR SIGNAL

FIG.5

BD

PHS 1   PHS 2
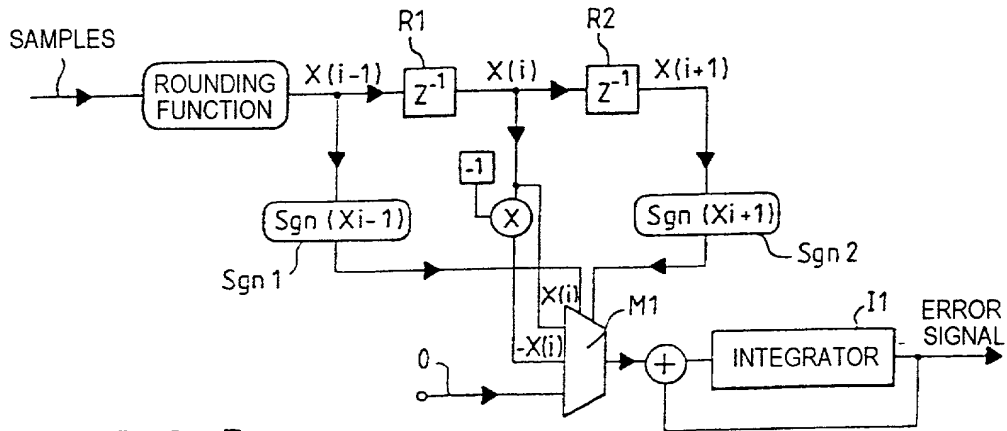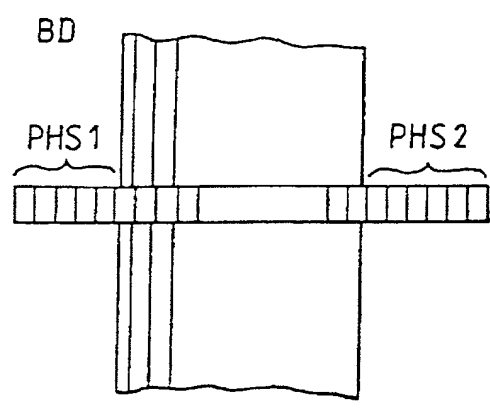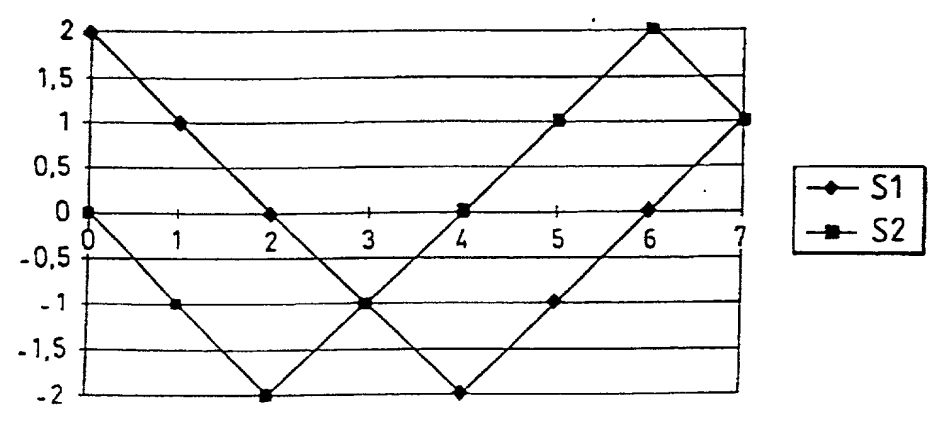
FIG.6

FIG.7
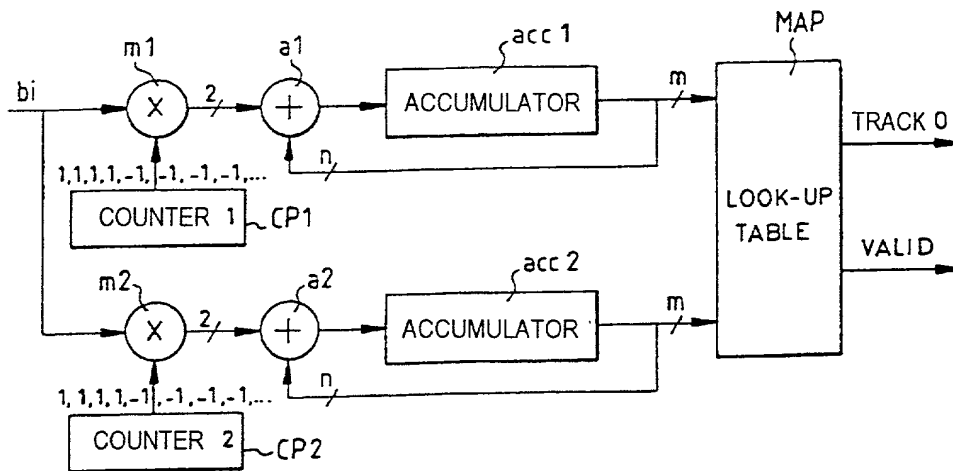
FIG.8

Declaration and Power of Attorney for Patent Application
Déclaration et Pouvoirs pour Demande de Brevet
French Language Declaration

En tant l'inventeur nommé ci-après, je déclare par le présent acte que:

As a below named inventor, I hereby declare that:

Mon domicile, mon adresse postale et ma nationalité sont ceux figurant ci-dessous à côté de mon nom.

My residence, post office address and citizenship are as stated next to my name.

Je crois être le premier inventeur original et unique (si un seul nom est mentionné ci-dessous), ou l'un des premiers co-inventeurs originaux (si plusieurs noms sont mentionnés ci-dessous) de l'objet revendiqué, pour lequel une demande de brevet a été déposée concernant l'invention intitulée

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

_____

_____

_____

TRACK-FOLLOWING SYSTEM FOR THE

RECORDING/READING OF A DATA MEDIUM

AND RECORDING MEDIUM

et dont la description est fournie ci-joint à moins

the specification of which:

☐ ci-joint

☐ is attached hereto.

☐ a été déposée le _____

☒ was filed on __July 9, 1999__

sous le numéro de demande des Etats-Unis ou le numéro de demande international PCT

as United States Application Number or PCT International Application Number

_____ et modifiée le

PCT/FR99/01690 and was amended on

_____ (le cas échéant).

_____ (if applicable).

Je déclare par le présent acte avoir passé en revue et compris le contenu de la description ci-dessus, revendications comprises, telles que modifiées par toute modification dont il aura été fait référence ci-dessus.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

Je reconnais devoir divulguer toute information pertinente à la brevetabilité, comme défini dans le Titre 37, § 1.56 du Code fédéral des réglementations.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

French Language Declaration

Je revendique par le présent acte avoir la priorité étrangère, en vertu du Titre 35, § 119(a)-(d) ou § 365(b) du Code des Etats-Unis, sur toute demande étrangère de brevet ou certificat d'inventeur ou, en vertu du Titre 35, § 365(a) du même Code, sur toute demande internationale PCT désignant au moins un pays autre que les Etats-Unis et figurant ci-dessous et, en cochant la case, j'ai aussi indiqué ci-dessous toute demande étrangère de brevet, tout certificat d'inventeur ou toute demande internationale PCT ayant une date de dépôt précédant celle de la demande à propos de laquelle une priorité est revendiquée.

I hereby claim foreign priority under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below, and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
Demande(s) de brevet antérieure(s) dans un autre pays

		Priority claimed Droit de priorité revendiqué	

98 07584	FRANCE	16 JUNE 1998	☐ Yes Oui	☒ No Non
(Number) (Numéro)	(Country) (Pays)	(Day/Month/Year Filed) (Jour/Mois/Anné de dépôt)		

			☐ Yes Oui	☐ No Non
(Number) (Numéro)	(Country) (Pays)	(Day/Month/Year Filed) (Jour/Mois/Anné de dépôt)		

Je revendique par le présent acte tout bénéfice, en vertu du Titre 35, § 119(e) du Code des Etats-Unis, de toute demande de brevet provisoire effectuée aux Etats-Unis et figurant ci-dessous

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application No.) (N° de demande)	(Filing Date) (Date de dépôt)	(Application No.) (N° de demande)	(Filing Date) (Date de dépôt)

Je revendique par le présent acte tout bénéfice, en vertu du Titre 35, § 120 du Code des Etats-Unis, de toute demande de brevet effectuée aux Etats-Unis, ou en vertu du Titre 35, § 365(c) du même Code, de toute demande internationale PCT désignant les Etats-Unis et figurant ci-dessous et, dans la mesure où l'objet de chacune des revendications de cette demande de brevet n'est pas divulgué dans la demande antérieure américaine ou internationale PCT, en vertu des dispositions du premier paragraphe du Titre 35, § 112 du Code des Etats-Unis, je reconnais devoir divulguer toute information pertinente à la brevetabilité, comme défini dans le Titre 37, § 1 56 du Code fédéral des réglementations, dont j'ai pu disposer entre la date de dépôt de la demande antérieure et la date de dépôt de la demande nationale ou internationale PCT de la présente demande

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

PCT/FR99/01690	9 JULY 1999	(Status) (patented, pending, abandoned)
(Application No.) (N° de demande)	(Filing Date) (Date de dépôt)	(Statut) (breveté, en cours d'examen, abandonné)

(Application No.) (N° de demande)	(Filing Date) (Date de dépôt)	(Status) (patented, pending, abandoned) (Statut) (breveté, en cours d'examen, abandonné)

Je déclare par le présent acte que toute déclaration ci-incluse est, à ma connaissance, véridique et que toute déclaration formulée à partir de renseignements ou de suppositions est tenue pour véridique, et de plus, que toutes ces déclarations ont été formulées en sachant que toute fausse déclaration volontaire ou son équivalent est passible d'une amende ou d'une incarcération, ou des deux, en vertu de la Section 1001 du Titre 18 du Code des Etats-Unis, et que de telles déclarations volontairement fausses risquent de compromettre la validité de la demande de brevet ou du brevet délivré à partir de celle-ci.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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French Language Declaration

POUVOIRS: En tant que l'inventeur cité, je désigne par la présente l'(les) avocat(s) et/ou agent(s) suivant(s) pour qu'ils poursuive(nt) la procédure de cette demande de brevet et traite(nt) toute affaire s'y rapportant avec l'Office des brevets et des marquees. *(mentionner le nom et le numéro d'enregistrement).*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

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Signature de l'inventeur Date	Second inventor's signature *Christian Claudepierre* Date
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	91200 ATHIS-MONS FRANCE

(Fournir les mêmes renseignements et la signature de tout co-inventeur supplémentaire)

(Supply similar information and signature for third and subsequent joint inventors.)

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French Language Declaration

Nom complete de l'unique ou premier inventeur	Full name of third joint inventor, if any 3(2) **Michel AUDOIN** December 10, 2001
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Signature de l'inventeur Date	Fourth inventor's signature Date
Domicile	Residence
Nationalité	Citizenship
Adresse Postale	Post Office Address
Nom complete du second co-inventeur, le cas echeant	Full name of fifth joint inventor, if any
Signature de l'inventeur Date	Fifth inventor's signature Date
Domicile	Residence
Nationalité	Citizenship
Adresse Postale	Post Office Address
Nom complete du second co-inventeur, le cas echeant	Full name of sixth joint inventor, if any
Signature de l'inventeur Date	Sixth inventor's signature Date
Domicile	Residence
Nationalité	Citizenship
Adresse Postale	Post Office Address

(Fournier les mêmes renseignements et la signature de tout co-inventeur supplémentaire)

(Supply similar information and signature for third and subsequent joint inventors.)

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